STUDY ON KARST INFORMATION IDENTIFICATION OF QIANDONGNAN PREFECTURE BASED ON RS AND GIS TECHNOLOGY

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ABSTRACT:

Karst area is a pure natural resource base, at the same time, due to the special geological environment; there are droughts and floods alternating with frequent karst collapse, rocky desertification and other resource and environment problems, which seriously restrict the sustainable economic and social development in karst areas. Therefore, this paper identifies and studies the karst, and clarifies the distribution of karst. Provide basic data for the rational development of resources in the karst region and the governance of desertification. Due to the uniqueness of the karst landscape, it can't be directly recognized and extracted by computer in remote sensing images. Therefore, this paper uses the idea of "RS+DEM" to solve the above problems. this article is based on Landsat-5 TM imagery in 2010 and DEM data, proposes the methods to identify karst information research what is use of slope vector diagram, vegetation distribution map, distribution map of karst rocky desertification and other auxiliary data in combination with the signs for human-computer interaction interpretation, identification and extraction of peak forest, peaks cluster and isolated peaks, and further extraction of karst depression. Experiments show that this method achieves the "RS + DEM" mode through the reasonable combination of remote sensing images and DEM data. It not only effectively extracts karst areas covered with vegetation, but also quickly and accurately locks down the karst area and greatly improves the efficiency and precision of visual interpretation. The accurate interpretation rate of karst information in study area in this paper is 86.73%.

1. INTRODUCTION

Karst landform refers to the various forms of soluble rock (carbonate, gypsum, rock salt, etc.) formed under the action of karst role, the main of is water in chemical dissolution, and the assistive effect is the water erosion, erosion and collapse and other mechanical role (Shu, 2010). China is one of the largest karst development areas in the world. Karst landform is not only widely distributed and diverse types in China, but also development is very typical, especially in south-western Sichuan and Yunnan-Guizhou Plateau. Karst area is a pure natural resource base, a good place for oil and gas storage and storage, rich in mineral resources, springs have a lot of beneficial gases and elements, is still a good tourist resources, at the same time, due to the special geological environment, there are droughts and floods alternating with frequent karst collapse, karst rocky desertification and other resource and environment problems, seriously restricting the sustainable development of economy and society in the karst area (Sheng et al., 2016). At present, relative to other regions, Guizhou Province is an economically underdeveloped and sluggishly developed region with a low standard of living for the vast majority of its people. Its fundamental reason is closely linked to the fragile ecological environment of Guizhou. Therefore, for the rational development and utilization of resources in karst areas and the ecological management of karst rocky desertification in the study area, it is necessary to obtain the karst landform distribution in Guizhou Province as the data foundation. This paper uses Landsat-5 TM remote sensing data to identify the karst landforms of the Qiandongnan Miao and Dong Autonomous Prefecture of Guizhou Province, and to clarify the specific distribution of karst landforms. It provides basic data for the rational development of natural resources in the karst region and the governance of desertification areas.

In recent years, many achievements have been made in the research of karst, especially in the extraction of karst information from remote sensing images. In 2000, Lin Junqing made a visual interpretation of the karst landform and water system in Guizhou Province by using false color synthesis on satellite images. He also established the interpretation signs and interpretations sample map of the landforms and water system (Liu, 2000). In 2011, Liang Fuyuan et al. Using the ASTER image to successfully extract the DEM of high peak forest and deep karst depression in the Dahua area of Guangxi (Liang et al., 2010). In 2012, based on the background values of remote sensing images, Yang Shuwen et al. constructed an automatic remote sensing extraction model which can extract information of peak forest, peak cluster and solitary peak concisely and effectively and further extract karst depression information (Yang et al., 2012). In 2013, Huang Shufen et al. Used ALOS images to classify karst landforms automatically and classified them roughly, for the digital karst terrain information system to lay the foundation (Huang et al., 2013).

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2. STUDY AREA AND BASIC DATA

2.1 Study Area

Qidongnan Miao and Dong Autonomous Prefecture is located in the southeast of Guizhou Province. It is 240km from north to south and 220km from east to west. Its total area is 30,337km^2, accounting for 17.2% of the total area of the province. The territory is subtropical monsoon humid climate zone, with four distinct seasons, abundant rainfall, and obvious wet and dry weather. It has the characteristics of no cold in winter, no heat in summer, and the same season of rain and heat. According to the effects of stratum rock, geological foreign power, and monsoon climate, the territory can be divided into erosion landforms and karst landforms. In the northwest region from Zhenyuan to Kaili, common karst landforms include peak forests, peak clusters, stone forests, karst caves, karst depression and so on.

2.2 Basic Data

This article selects TM image of Landsat-5 in 2010, which belongs to optical image data. The image spatial resolution of TM images in red, green, blue, near infrared and shortwave infrared bands is 30 m, and only the longwave (the sixth band) spatial resolution of the is 120 m. Landsat-5 TM image data used in this paper is from the United States Geological Survey (https://earthexplorer.usgs.gov/). Landsat-5 TM images are used in this paper for the extraction of karst rocky desertification, vegetation and as a basis for visual interpretation.

ASTER GDEM data is the latest DEM data from NASA and METI in 2009. It has wide coverage and high accuracy. This article's DEM data is obtained from the geospatial data cloud. After the data of eight pieces of DEM are spliced and cut, the DEM image data of Qiandongnan Miao and Dong autonomous prefectures in Guizhou Province are obtained. Using its spatial analysis of the study area to generate slope map, as the basic data in the process of human-computer interaction interpretation.

3. METHODOLOGY

Due to the uniqueness of karst landform, the surface of karst area is very complex, and the surface gradient is quite different, which is different from Ordinary Mountain, and there are all kinds of bare rocks, vegetation, crops and so on. Therefore, the karst area can't be made once be identified and extracted. How to identify and extract the vegetation area in the karst landform in the remote sensing image and how to distinguish the vegetation area on the karst landform from the vegetation area on the non-karst landform are the key and difficult points in this paper. Therefore, this paper uses the idea of "RS+DEM" to solve the above problems. The specific steps are as follows:

Firstly, the remote sensing images and DEM data of the entire study area were obtained by pre-processing Landsat-5 TM image data and DEM data. The vegetation index (NDVI) was calculated, the vegetation cover map of the study area was extracted by the pixel dichotomy method, and the karst rocky desertification area was extracted by the decision tree method; Gradient analysis using DEM data to obtain slope map of study area; According to the geological data and Google Earth high-resolution image data to obtain the real surface area of interest in karst region, and through repeated interpretation and comparison of its various morphological features, a remote sensing interpretation of karst topographic interpretation in Qiandongnan Prefecture was established.

Secondly, reclassified the slope gradient greater than 22 °in the slope map, and superimposed with the vegetation area to remove the vegetation on the plain. The rest of the area which is the vegetation area with slope greater than 22 ° is used as the basic data for visual interpretation and analyzed with the karst rocky desertification area; Get the general distribution of karst regions.

Finally, using the general distribution of karst regions and karst rock desertification area for analysis and processing, and then with the establishment of the karst logo information and other auxiliary information for human-computer interaction interpretation, identify and extract peak forest, peak cluster and isolated peak, further extraction of karst depression. Get the karst topography map of Qiandongnan Miao and Dong Autonomous Prefecture in Guizhou Province. Figure 1 shows the technical route.

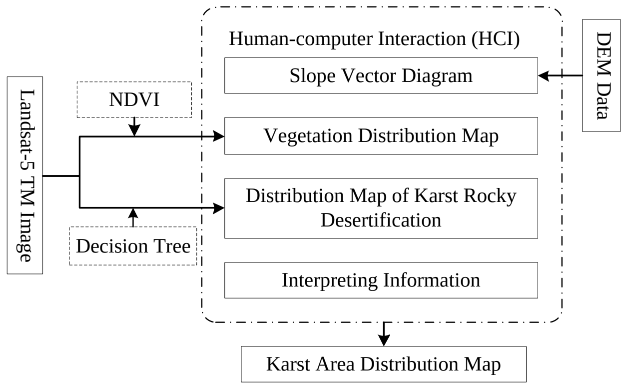

Figure 1. Technology roadmap

4. DATA PROCESSING AND EXTRACTION ANALYSIS

This article completes the correction of the four Landsat-5 TM image data in the study area, including radiation correction, FLAASH model atmospheric correction, and geometric correction. Take a simple and fast method is used to seamlessly stitch 4 images. Finally, the area image of the study area is cut out based on the vector data.

4.1 Slope Analysis

As an important index to describe the topographic features, the slope not only can represent the topography and structure of the ground surface, but also can be used as basic data for geo-analysis of hydrological models, landslide monitoring and analysis, surface material movement, soil erosion and land use planning (Liu et al., 2013). There are five methods for calculating slope, such as space vector analysis method, quartering method, fitting plane method, fitting surface method and direct solution method. Among them, the fitting surface method works best. In this paper, DEM is used to describe the gradient of topography. In order to ensure the accuracy of the operating window in order to improve the accuracy of the terrain analysis (Zhou et al., 2016), the surface usually adopts a 3 × 3 window centered on the elevation point as shown in Figure 2.

The *slope* calculation formula is:

$$slope = \tan\sqrt{S_x^2 + S_y^2} \quad (1)$$

where *slope* = the slope value
S_x = the slope in the *x* direction
S_y = the slope in the *y* direction

$$S_x = \frac{(e_8 + 2e_1 + e_5) - (e_7 + e_3 + e_6)}{(8 \times cellsize)} \quad (2)$$

$$S_y = \frac{(e_7 + 2e_4 + e_8) - (e_6 + e_2 + e_5)}{(8 \times cellsize)} \quad (3)$$

e5	e2	e6
e1	e	e3
e8	e4	e7

Figure 2. DEM 3×3 window

Through the processing of the DEM data in the study area, the slope analysis results of the study area are obtained. By reclassifying the study area slope maps, the slopes are classified into slopes of 0 °-22 °and slopes of 22 °.

4.2 Vegetation NDVI Index Extraction

In this paper, the vegetation coverage area is obtained by calculating the normalized vegetation index (NDVI) of remote sensing images and using NDVI to establish a binary model of the pixel (Li et al., 2004; Zhao, 2013). The *NDVI* is:

$$NDVI = \frac{NIR - Red}{NIR + Red} \quad (4)$$

where *NIR*= the near-infrared band
Red= the red band

For the main coverage of the land surface, clouds, water and snow have higher reflectance in the visible band compared to the near infrared band, and their *NDVI* values are negative. Soil rocks have similar reflectivities in these two bands, so their *NDVI* values are close to zero. In the case of vegetation cover, the *NDVI* value is positive and increases with the increase of vegetation cover (Lin et al., 2007).

Pixel bipartite model assumes that a pixel is composed of two parts of soil and vegetation information, and the information sensed by remote sensing sensor expresses the sum of the information contributed by green vegetation component and the information contributed by soil component. Based on the NDVI pixel bipartite model can be expressed as:

$$f_c = \frac{(NDVI - NDVI_{soil})}{(NDVI_{evg} - NDVI_{soil})} \quad (5)$$

where $NDVI_{veg}$= the NDVI value of the pure vegetation soil pixel
$NDVI_{veg}$= the NDVI value of the pure vegetation coverage pixel
f_c = the vegetation coverage of pixels

As the experiment will produce some unavoidable outliers, the maximum and minimum values are generally outliers. Therefore, the number of pixels that accumulate up to 2% of the total number of pixels in the selected number is the minimum value $NDVI_{soil}$, the value of the pixel whose cumulative value reaches 98% is the maximum value $NDVI_{evg}$, and the f_c represents the vegetation coverage of pixels.

The vegetation coverage f_c of the pixel is calculated, and part $f_c \geq 0.5$ (ie, the part where the green vegetation component accounts for half or more of the picture element) is divided into vegetation coverage areas.

4.3 Karst Rocky Desertification Extraction

Due to the supervised classification method, it is inaccurate to distinguish between exposed soil and exposed rock in remote sensing images. Therefore, this paper adopts the method of decision tree to interpret and classify the research area, so as to obtain the rocky desertification area. Decision tree is a hierarchical processing structure in remote sensing image classification and is suitable for distinguishing complex and fuzzy features in remote sensing images. Its basic idea is to separate and mask each target gradually from the original image, as a layer or branch, to avoid the interference and impact of this target on the extraction of other targets. Finally compound all the layers to achieve automatic image classification (Wang & Li, 2002).

Specific classification extraction steps are as follows: Firstly, input remote sensing images and establish regions of interest in the study area to train major feature types. Secondly, the root node is determined by statistically characterizing information in various areas of the training area, including spectral information and non-spectral information, the use of classifiers to be divided into bare land, residential areas, water, and vegetation. Finally, an internal node of the decision tree is established by combining features (height, texture, slope, etc.) and band or band combinations with relatively large separability in the bare land obtained in the previous step, and classified according to different attribute values. The karst rock desertification area in the study area was finally extracted.

5. IDENTIFICATION INTERPRETATIONS

5.1 Remote Sensing Interpretation Signs

For human-computer interactive interpretation of karst information, visual interpretation is the most important and decisive factor. The premise of visual interpretation is to obtain the interpretation of information, that is, interpretation of the signs. In order to obtain the interpretation of information, this article through the integration of study area geomorphological auxiliary data access karst interpretation signs.

Landsat-5 satellite image data and Google Earth data are used to interpret and compare the characteristics of karst topography such as morphology, size, shadow, texture, color, pattern, location and surrounding environment (Zhou, 2009; Huang et al., 2013). The image features of karst topography are shown in Table1. In this paper, the main types of surface karst identified as peak forest, peaks cluster, isolated peaks and karst depression.

Among them, the stone buds and the karrens can be recognized only by the stereoscopic observation on the high-resolution images, and the landsat-5 TM image in this paper has low resolution and can’t be identified.

Landform type	peak forest	peaks cluster	karst depression	isolated peaks
Image				
Characterization	The base of the mountain is slightly connected or completely separated, which is an independent stone peak. The relative height of the stone peak is 100-200m.	Large mountain body, connected to the bottom, the top by strong erosion and erosion, the formation of many pinnacles.	Most of the lowland in Guizhou is cultivated land, often surrounded by steep peaks, and the bottom is flatter.	Pinnacles dispersed, stand in isolation in the karst plain or large piers basin.
Image features	The image is dark and densely dotted, showing dark or irregular clusters of dark patches.	Images appear pimple-shaped, "orange peel" shape, "peanut shell" -like pattern (Li, 1990)	Light-colored patches or bands; beaded depressions or rhomboid motifs when their development is controlled by large joints.	Conical shape, the terrain was single-sided mountain (zhu, 1994).

Table1. Table of karst landform image characteristics

5.2 Interactive interpretation

This paper uses human-computer interaction (HCI) method to interpret the karst information of the Qiandongnna Miao and Dong Autonomous Prefecture in Guizhou Province. Due to the uniqueness of the karst landscape, it can’t be directly recognized and extracted by computer in remote sensing images. this paper using of slope vector diagram, vegetation distribution map, distribution map of karst rocky desertification and other auxiliary data in combination with the signs for human-computer interaction interpretation, identification and extraction of peak forest, peaks cluster and isolated peaks, and further extraction of karst depression. The specific steps are as follows: (1) Spatial overlay analysis of vegetation distribution maps and slope maps to extract vegetation areas with slope than 22°; (2) Spatially union analysis of vegetation areas with slope than 22° and rocky desertification areas to lock up the approximate range of the karst area; (3) Visual interpretation of the approximate range of the karst areas combine with geological ancillary data and interpretation signs, and karst peak clusters, peak forests, and solitary peak areas were extracted; (4) Combine interpreting signs to further extract karst depressions, the final depiction of plaque in the karst area. The Human-computer interaction interpretation process map as shown in Figure 3.

5.3 Results

Karst area can be calculated after the plot of the study area is completed. Karst area and karst rocky distribution area of Qiandongnan Miao and Dong Autonomous Prefecture in Guizhou Province, China in 2010, as shown in Figure 4, and all the karst patches are extracted and overlaid onto the Landsat image of the Miao and Dong Autonomous Prefecture in Guizhou Province. The distribution of karst topography in the Qiandongnan Miao and Dong Autonomous Prefecture is obtained, which shows the distribution characteristics of the karst area. All karst plaques are represented on the Arc GIS platform.

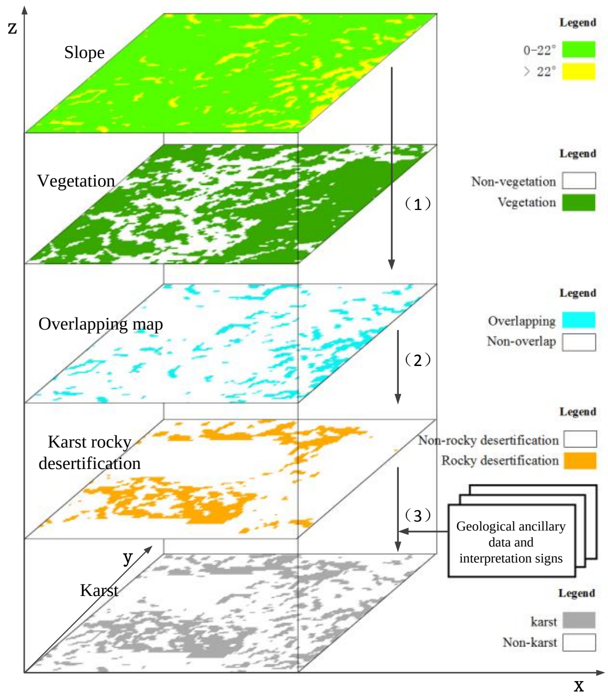

Figure 3. Human-computer interaction interpretation process

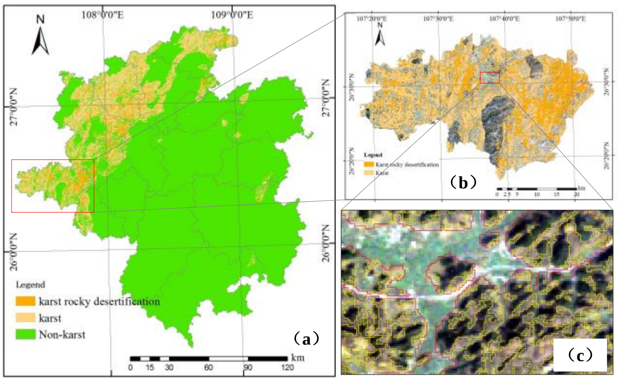

Figure 4. Karst area and karst rocky distribution area of Qiandongnan Miao and Dong Autonomous Prefecture in Guizhou Province, China in 2010; with the human-computer interaction interpretation above, a thematic map of karst of study area has depicted in Fig. 4(a). A thematic map of karst area and karst rocky distribution area of Majiang County has depicted in Fig. 4(b). A zoom-in window is enlarged in Fig. 4(c); with the yellow area in the figure is the karst rocky distribution patch, and the red area in the figure is the karst patch.

Through statistical calculation, it can be learned that the area of karst area in Qiandongnan is 6129.86km^2. According to the data, the total area of karst in Qiandongnan Miao and Dong Autonomous Prefecture in Guizhou Province in 2010 was about 7067.75km^2, the relative area accuracy was 86.73%, the precision of identification and interpretation of karst information obtained in this paper was about 86.73%. This accuracy index is low relative to the results of multispectral modeling, due to the lack of information and human subjectivity in visual interpretation.

6. CONCLUSION

This article proposes the methods to identify karst information research what is use of slope vector diagram, vegetation distribution map, distribution map of karst rocky desertification and other auxiliary data in combination with the signs for human-computer interaction interpretation, identification and extraction of peak forest, peaks cluster and isolated peaks, and further extraction of karst depression. This method can quickly and accurately lock down the scope of karst area; greatly improve the efficiency and accuracy of visual interpretation. The various thematic maps obtained from the Landsat-5 TM satellite image and DEM image data can be used to provide a data basis for other studies in the study area.

This article also has some shortcomings. Such as the use of human-computer interactive interpretation of subjectivity is greater than the phenomenon of objective interpretation, interpretation accuracy will have an impact. In this paper, the remote sensing image data and DEM data are both 30m precision, the accuracy is relatively low, and some of the classic small and towering stone bud can’t be identified.

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